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1853 / 1953

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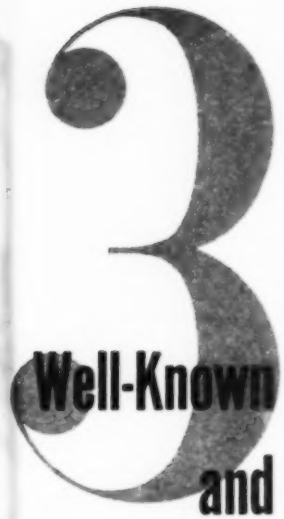

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Vol. 29 December, 1952 No. 12

A STUDY OF DEPTH PERCEPTION IN THE LIGHT AND DARK ADAPTED EYE*

Elton J. Gumbel†
Chicago College of Optometry
Chicago, Illinois

INTRODUCTION.

In spite of the great progress made in recent years in the field of physiological optics, many basic problems are still unsolved, and many tentative hypotheses still remain to be tested. One of these is the current concept that the perception of depth is primarily a function of cone vision, that is, of the light adapted eye. Studies of depth have been limited to investigations involving visual acuity, subdued illumination, and monocular and binocular cues which aid in the perception of depth. These studies have substantiated the superiority of cone function over rod function in depth perception.

It is a familiar fact that rod vision in its crude and primitive stage, operating as it does at low intensities of light is incapable of acute discrimination involving form acuity. The same is true of precise localization.[1, 2]

Studies of these factors have been correlated and rather clear-cut theories have been evolved. Those involving depth discrimination under reduced illumination have been numerous and most outstanding. They seem conclusive, but no attempt has been made to determine the degree to which depth discrimination exists in a dark-adapted eye when the stimuli are below the photopic threshold. It has been postulated by Mueller and Lloyd[3] that some judgments of depth can be made at brightnesses below the cone threshold.

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*A thesis submitted to the faculty of the Division of Graduate Studies of the Chicago College of Optometry in partial fulfillment of the requirements for the degree of Master of Science in Optometry.

The courtesy and cooperation of the American Optical Company is acknowledged. The loan of their equipment to the Chicago Strabismus Project made this study possible. The author acknowledges the faculty guidance of Dr. Z. B. Schoen and Dr. Thaddeus Murroughs.

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†Optometrist and graduate student.

Photopic vision, which is maximal at the fovea, requires that the energy of a stimulus remain at a constant level, otherwise the photopic function is greatly reduced. Although rod and cone functions overlap, rod vision is absent at the center of the retina. Rod vision operates most effectively with stimuli of low intensities 6 to 10 degrees from the fovea, when form acuity must be considered along with the perception of light.[1, 7]

This zone which has a low threshold of irritability was chosen for investigation to determine whether any correlation exists between the functions of the non-dominant and dominant eye, and the binocular percept insofar as depth discrimination or stereopsis exists in the dark-adapted eye.

Investigation of the literature reveals little indication that depth perception exists at the level of dark-adaptation being investigated in this experiment. Evidence for this factor, then, is meager and not conclusive, but certain studies lend support to the hypothesis that some type of depth perception exists in scotopic vision.

According to Weymouth and Hirsch[2] significant depth differences were found to exist with a brightness of .0025 millilamberts (within the scotopic range). The average threshold was 78.45 millimeters when measured on the Howard-Dohlman apparatus. Mueller and Lloyd[3] concluded that depth discrimination is possible below the cone-rod threshold. The analysis of their data is discussed in terms of brightness discrimination and visual acuity developed on the curve of Hecht and Mintz. Though this experiment parallels that of Mueller and Lloyd, it differs in that they were interested in a theoretical consideration of the changes in stereo-acuity based on varying degrees of illumination. In this experiment the observers were kept completely dark-adapted and the brightness was kept constant.

The paucity of experimental work in this field served as an added incentive for undertaking the present study. The purpose is to determine what differences exist between the dominant, non-dominant and binocular percept in both scotopic and photopic vision.

Unlike the dark-adapted eye under the conditions of low brightness the light-adapted eye perceives depth, both monocularly and binocularly to a higher degree. The superiority of binocular depth perception over monocular depth perception is very apparent.

THEORETICAL CONSIDERATIONS OF FACTORS INVOLVED IN DEPTH DISCRIMINATION

A. *Monocular Factors*

1. Size and detail of the retinal image. Through experience we

have learned that the larger and sharper the image, the nearer the object. This is primarily a function of the light-adapted eye and will be considered in more detail later.

2. The clues from accommodation in which the lens focus is altered to give a clear image are presumed to give proprioceptive impulses which furnish a clue to distance. However, since neither the receptors nor the afferent nerve fibers have ever been demonstrated, and since accommodation clues are insignificant when other clues to distance are removed there is some doubt as to the validity of this claim.

3. Light and shade. Light from an object is interpreted as being near the source of illumination and the shadows farther away.

4. Border clarity. Objects with sharp outlines are perceived as nearer than those that are indistinct.

5. Interposition. If one object obscures another partly from view, the latter will appear more distant.

6. Motion parallax — when the head is moved from side to side far objects appear to move in the same direction, and nearer objects seem to move in the opposite direction. The head is held fixed in a chin-rest in this experiment to avoid this clue.

7. Mathematical perspective — grading the sizes of a number of objects to represent their varying distances.

Note: Factors 3, 4, 5 and 7 are not present in this experiment.

B. Binocular Factors

1. Binocular parallax. This is the difference in the geometry of seeing and exists only when both visual axes are directed towards the object of regard. Figure 1.

2. Convergence functions as a clue when both visual axes are

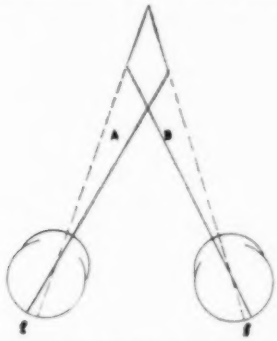

Fig. 1. Illustrating Binocular Parallax. Angle A plus Angle B equals the Parallactic Angle.

directed to the same point in space. In the scotopic section of this experiment the axes are directed to a lateral position. Judgment of distance in the dark-adapted eye is dependent upon the size and detail of the retinal image, brightness discrimination and accommodation.

Accommodation as a factor supposedly does not function beyond the distance chosen.[5] Craik[6] has shown that as adaptation proceeds with decreased illumination, brightness discrimination and visual acuity deteriorate far below the level to which the eye is dark-adapted i.e., the ability to discriminate brightness differences in the dark-adapted eye is absent.

Since the size and detail of the retinal image are decidedly the most important factors, a series of tests was devised by which observers attempted to use these factors as clues. The inconsistency of the responses was so apparent that these clues were eliminated from consideration. There was no intention of ignoring any of the factors which aid in the perception of depth but if depth discrimination is found to be better binocularly than monocularly it must be concluded that the binocular factors are more important.

Additional Factors

It is conceivable that a function other than depth discrimination is being measured in a dark-adapted eye i.e., spatial localization, brightness contrast of equally bright objects placed at different distances, cerebral dominance or retinal image sizes.

1. As a problem in spatial localization this study parallels that of Schoen.[1] In this study the dominant eye was superior to the non-dominant, the differences being significant at the 5% level. However, the binocular response was vastly superior in the accuracy of lateral localization of objects in space under scotopic conditions. Here too, the same subjective comment was found that there is a striking superiority binocularly, in both confidence of accuracy and facility of response.

2. It is difficult to concede that cerebral dominance[5] was also being tested. The requisite controlled fixation insured that a constant area of the retina was stimulated. The lateral position of the fixation point causes stimulation of a temporal portion of the retina of the dominant eye, by the targets. This has a cerebral interpretation on the corresponding side as opposed to a nasal portion which is represented in the opposite hemisphere (Figure 2) due to the decussation of the nasal fibers.

Since size and detail have been eliminated and no other effective clues were available in the dark, no emphasis can be placed on the experience factor. Only the factor of depth discrimination remained, and

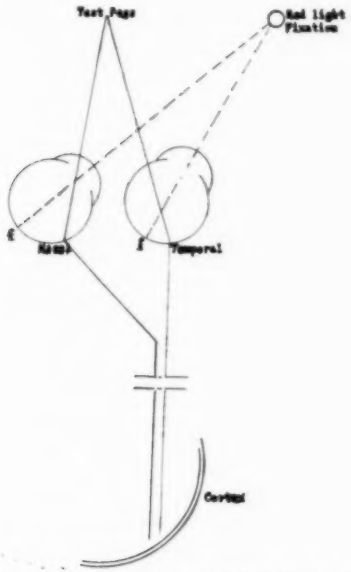

Fig. 2. Cortical Stimulation. Because of the semidecussation of the optic nerve fibers, stimulation of the nasal portion of one retina and a temporal portion of the other has a cortical interpretation in the cortex corresponding to the temporal portion.

whether it is a cortical or subcortical function is unimportant in this study.

Apparatus

The Howard apparatus was selected for this experiment since it is conventionally used in studies dealing with judgments of depth, in spite of certain criticisms. It should be pointed out that these criticisms may not apply to the use of the apparatus in studying depth perception at the scotopic level. A few modifications were added to the relatively simple specifications as set up by Howard.[9] See Figure 3.

The framework consists of three sides of a box, back, bottom and front, measuring 58 cm. high and 75 cm. wide; the floor was 55 cm. from the front to back and 75 cm. wide.

The top and one side of the apparatus are closed, except for the side on which the experimenter works. Both surfaces of the front partition and floor are painted black. The front surface of the back partition was covered with a coat of non-glossy white paint.

In the center of the front surface a window was cut 20 cm. wide

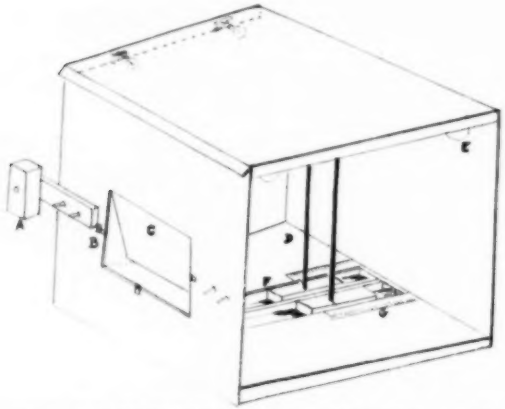

Fig. 1. Apparatus. A. Red light fixation point. B. Filter holder. C. Trap. D. Test pegs. E. Light bulbs. F. Troughs with sliding blocks. G. Phosphorescent centimeter scale.

and 12 cm. high, with the upper margin 29.5 cm. from the top. This window subtends an angle of 3°40′ in the horizontal and 2°17′ in the vertical. The window is equipped with a trap which can easily be opened and closed in order to prevent the observer from seeing the resetting of the pegs.

Extending from the front to the back in the center of the floor are two troughs, 33 mm. deep and 47 mm. wide. A block with a peg mounted on it is set in each trough. The blocks can be slid the full length of the troughs.

The pegs are 12 mm. (visual angle of 14′) in diameter and at least 50 cm. in length. They are very smooth and painted a dull black. For the photopic part of the experiment the pegs are illuminated by four 40 watt bulbs, placed equally around the upper margin of the apparatus. For the scotopic part of the experiment two radium plaques* 2.5 cm. (visual angle of 4°46′) wide and 15 cm. in length are used. The manufactured brightness of the plaques is .01 millilambert.*

A filter measuring 14x22 cm. was placed in the window of the apparatus in order to cut down the brightness to the point where 10-15 minutes of adapting in the dark was required to just see the pegs. Since the filter had a transmission of 10% it is estimated that the level of illumination was .001 millilamberts. The radium plaques could not be seen by the dark-adapted eye by using direct fixation.

*Manufactured by United States Radium Corporation, New York, N. Y.

Two phosphorescent millimeter scales were mounted on the floor along each outer side of the troughs. The zero point of each scale was placed at the midpoint of each trough.

In line with the center of the vertical opening a small red light was placed to control the fixation, 33 cm. or 6° from the center of the window in a horizontal position. This light could be transposed to either side of the window as required. The position of the observer's head was held constant with the aid of a chin and head rest.

Adaptation Procedures

All observers were properly light-adapted for three minutes. Since adaptation with any type of goggles shortens the time in the dark-room red non-polarizing goggles were used. These had a "cut-off" point of 592 millimicrons with a photopic transmission of 7.70%.[10]

The eye to be tested was light-adapted to a high brightness for three minutes, then the observers donned the red goggles and wore them for 15 minutes. Before removing the goggles the observer was taken into complete darkness for another 10-15 minutes to dark-adapt him sufficiently for the purposes of this experiment. The eyes were then tested alternately. The red-light fixation point was placed on the side corresponding to the eye that was being tested.

Factors Encountered in Dark-Adaptation

The preparation of observers for the scotopic portion of this experiment coupled with certain phenomena encountered in the dark, makes the procedure tedious and laborious.

Whereas individual differences are found in dark-adaptation time, a filter was chosen to cut down the brightness to a level so that approximately 10-15 minutes had to be spent in the dark, after the pre-adaptation period of 15 minutes with the red goggles. This insured the use of scotopic vision. The central rod scotoma was an added guarantee.

Prolonged fixation of the foveal point caused autokinetic movements of the red light which acted as a deterrent to an immediate and correct judgment. Once this occurred and the test pegs were exposed there was a definite attempt to localize the fixation point first and then interpret the relative position of the pegs. After a "ready signal" the observer fixated the red light and then made his judgment. Occasional blurring or fading of the pegs could be avoided only by a rest period of 20-30 seconds.

Method of Procedure

The light-adapted part was carried out in the dark-room with the light of the apparatus as the source of the illumination. The observer sat

in a chair 3 meters from the pegs, with his head held firmly by the chin and head rest. The apparatus was placed on an adjustable table so that the eyes were on line with the center of the vertical and horizontal opening of the front partition. This eliminated any opportunity to utilize clues of linear perspective. When the trap was raised, neither the top or bottom of the pegs was visible.

The observer simply had to report which peg was the closer. Ten judgments were made for *each* separation. The separations chosen were 1 millimeter increments beginning with 2 millimeters separation, then 5 mm. separations from 5 to 100 mm.; one was added at 110 in the light-adapted portion. The separation chosen for the dark-adapted part was 5 mm. increments beginning at 5 mm. to 100 mm. Two were added at 120 and 140 mm. separation.

Before experimentation began, each observer was informed that at no time would the pegs be set in the same plane or in any rhythmical presentation. A system of randomization was employed involving the use of 10 playing cards, five marked "L" and five marked "R." These were shuffled at each separation and the position of the rods determined in order of their occurrence. This means that either the right or left peg is moved to the designated position while the other is at the zero point.

Determination of Ocular Dominance

Four of the five subjects showed right eye dominancy. Dominancy was determined by responses to the following tests:

1. Binocular test. The observer is given a card measuring 8x12 inches with a hole, 1 inch in diameter in the center. He is told to fixate a light at a distance of 6 meters and bring the card up along the midline of the body until he is able to see the light through the hole. The observed position of the light determines the dominant eye.

2. Cone test. A small megaphone is given the observer; he is told to fixate the light through the large end of the megaphone. The observed eye through the small end determines the dominant eye.

3. Physiological diplopia. Two pencils are held in front of the observer at about arm's length. He is told to fixate the farther of the two. An individual with a normal binocular pattern of seeing will see the nearest pencil in heteronymous diplopia. While fixating the farthest pencil, the observer is asked to touch one of the two nearer images. Should he be successful he has touched the image of the dominant eye.

Observers

The five observers were untrained students of the Chicago College of Optometry ranging from 21-29 years of age. The primary requisites

were that each be free from ocular pathology and have 20/20 vision without any ophthalmic aid.

Results

The data used in the analysis are the number of correct responses for each separation of the pegs. For the five subjects used, a total of 32 correct responses out of 50 is required for significance at the 5% level (to be above the level of accidental guessing). The calculated results for the five subjects are shown in Tables I-II respectively for the light- and dark-adapted responses. Table III shows the results of the non-dominant, dominant and binocular responses in the light- and dark-adapted states.

Table I shows that under conditions of light adaptation there is a better performance binocularly than monocularly without question. This is in agreement with previous studies reported in the literature. The statistical analysis of the data shows means of 33.55, 30.29 and 47.20 correct responses out of 50 for the non-dominant, dominant and binocular tests respectively. On comparing these results in terms of critical ratios the binocular judgment is highly significant with "t" values of 7.76 and 9.13 as compared to the non-dominant and dominant eye respectively.

TABLE I

STATISTICAL ANALYSIS OF DATA. LIGHT ADAPTED

	Mean	σ	σm
Non-dominant	33.55	± 6.71	1.26
Dominant	30.29	± 6.69	1.39
Binocular	47.20	± 3.70	1.23

CRITICAL RATIO

	Mean	σ diff.	Critical Ratio "t" value	Level of significance
Non-dominant Dominant	33.55 30.29	1.88	1.73	None
Binocular Non-dominant	47.20 33.55	1.76	7.76	Very high
Binocular Dominant	47.20 30.29	1.85	9.13	Very high

The critical ratio of 1.73* between the non-dominant and dominant eyes shows no statistical significant difference between the two means of 33.55 and 30.29 in the light-adapted eye. This means that on the whole, judgments made on the basis of clues from one eye are not significantly better than those made by the other eye. Although a graph of the two shows a close relationship between the two sets of judgments

*2.93 is significant in this experiment.

the performance of the non-dominant eye becomes better at a separation of 30 mms. A consistently correct judgment for the dominant eye does not appear until a separation of 60 mm. is reached.

Table II shows the data of the dark-adapted part of this experiment. The means of 27.82, 29.42 and 32.74 were obtained for the non-dominant, dominant and binocular responses respectively. The binocular performance shows its superiority when compared to the non-dominant and dominant with critical ratios of 3.39 and 2.22 respectively being significant at the 1% and 4% levels. A graphical plot of these findings shows a rudimentary form of depth perception to exist in the binocular response becoming statistically significant at a separation of 60 mm.

TABLE II
STATISTICAL ANALYSIS OF DATA. DARK ADAPTED

	Mean	σ	σm
Non-dominant	27.82	± 3.47	0.87
Dominant	29.42	± 3.64	0.91
Binocular	32.74	± 4.67	1.17

CRITICAL RATIO

	Mean	σ diff.	Critical Ratio	Level of significance
Non-dominant Dominant	27.82 29.42	1.34	1.14	None
Binocular Non-dominant	32.74 27.82	1.45	3.39	1%
Binocular Dominant	32.74 29.82	1.49	2.22	4%

No significant or set pattern of distance discrimination could be identified in either the dominant or non-dominant eye. The non-dominant eye remains below the statistical level of significance while the dominant eye appears to show a slight trend towards significance. The difference between means (29.42 — 27.82 equals 1.60) is negligible as the critical ratio is found to be 1.14. This low critical ratio shows that depth perception is no better with the dominant eye than with the non-dominant eye in a dark-adapted state.

TABLE III
STATISTICAL ANALYSIS OF DATA. LIGHT AND DARK ADAPTED
CRITICAL RATIO

	Condition	Mean	σ diff.	Critical Ratio	Level of significance
Non Dominant	Light Dark	33.55 27.82	1.53	3.72	1%
Dominant	Light Dark	30.29 29.42	1.66	0.69	None
Binocular	Light Dark	47.20 32.74	1.69	8.55	Very High

It is instructive to compare the three separate performances in terms of response under light- and dark-adapted conditions (Table III). The performance of the non-dominant eye shows a significantly better result at the 1% level for the light-adapted eye with a critical ratio of 3.72.

Comparing the significant rudimentary binocular depth perception under dark-adapted conditions to binocular responses under light-adapted conditions, the high critical ratio of 8.55 shows a definite superiority of depth judgments under light conditions.

SUMMARY

1. Analysis of the data, based on correct responses, brings out the superiority of cone function over rod function in depth perception.

2. Binocular depth perception in the dark-adapted eye is shown to exist in a rudimentary form below the cone-rod threshold.

3. The binocular function shows its superiority by the high critical ratios that were found when compared to the monocular functions, in both light- and dark-adapted situations.

4. Monocularly, no set pattern of discrimination can be found in either the light- or dark-adapted state even though the responses reach statistical significance.

5. The line of demarcation between the patterns of the non-dominant and dominant eye cannot be determined on the basis of the present investigation.

6. The possibility that other factors are being tested is brought out for further consideration.

203 LINCOLN BUILDING
KANSAS CITY, MISSOURI

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PSYCHOLOGICAL FACTORS IN VISUAL ACUITY*

Glenn A. Fry†
School of Optometry, The Ohio State University
Columbus, Ohio

INTRODUCTION

Psychological factors in visual acuity can be differentiated from other factors, such as the coarseness of the retinal mosaic, the blurredness of the optical image formed on the retina, the fine oscillations of the eye which constitute in effect an additional source of blurredness, and interaction between the retino-cortical pathways.

There are at least three types of psychological factors that have to be considered in ordinary subjects using one eye at a time. One factor is the interpretation of blurred retinal images. Another factor is the change in sharpness of the optical image on the retina produced by changes in accommodation and pupil size induced by an effort to see. Still another factor which can be differentiated is an effect upon the brightness difference threshold produced by a change in intraocular pressure induced by a change in the accommodative mechanism when an effort is made to see.

In cases of amblyopia ex anopsia and congenital and hysterical amblyopia, additional psychological factors have to be considered.

Furthermore, when both eyes are used at the same time, the situation is further complicated by binocular rivalry, and suppression of vision in one eye.

THE INTERPRETATION OF BLURRED RETINAL IMAGES

The operation of this factor is fairly well understood. It comes into play in the ordinary test for visual acuity which employs Snellen letters. For example, T can be differentiated from Y and M from N even though the letters are quite blurred. The differentiation is based upon the general configuration of the distribution of intensity on the retina. As might be expected, skill of this sort can be improved by training.

If one wants to emphasize the importance of this factor, visual acuity targets can be designed with this in mind. An example is a test which involves differentiation of squares from discs and triangles.

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†Optometrist, Ph.D., Director of School, Fellow, American Academy of Optometry.

On the other hand it is possible to design a test which avoids the operation of this factor. If a single dot or a single narrow bar is used, and if the criterion is whether it is seen or not seen, the interpretation of the configuration of the blurred image is not a factor. Also when a pair of concentric rings is used and glasses are worn which provide a correction for astigmatism, the resolution of the rings depends upon the visibility of the gap between them. This again is an all-or-none affair which does not involve the interpretation of blurred imagery.

THE EFFECT OF AN EFFORT TO SEE

If a person stands before a window covered by a wire screen, he may either accommodate for the wire screen or look through the screen at a distant object and can voluntarily switch back and forth from one to the other. He is well aware of seeing one clearly, of making an effort to see the other, and then seeing it clear up as a result of his effort. However, when a subject is paying attention to an object at a given distance, he may be over or under accommodated for the object and not be aware of it. An effort to see it better may result in a more precise adjustment of the accommodative mechanism of the eye, and this may make it possible to see finer detail, but the observer may not be able to observe directly whether there has been any increase in the sharpness of optical image on the retina. In this type of situation it is necessary to use an indirect method to determine whether the effort to see actually induces a change in accommodation; and, once it is determined that a change in accommodation does take place, it is necessary to determine whether the improvement in acuity is to be attributed to changes in the sharpness of the optical image or to some other factor such as changes in intraocular pressure.

One can eliminate changes in intraocular pressure by paralyzing the eye with homatropine and then induce changes in blurredness of the optical image by using an artificial pupil and throwing the image out of focus with lenses placed in front of the eye. By this method one can determine to what extent the eye must be thrown in or out of focus to produce a given change in visual acuity.

If one attempts to use a target of high contrast, the effect of changes in sharpness of the optical image is so marked that other factors such as changes in intraocular pressure do not have a chance to become manifest. To a certain extent one can render changes in sharpness of the retinal image ineffective by using large targets of low contrast, and then if other factors than sharpness of the optical image play a role they will have a better chance to become manifest. Consider the case of a large pair of bars of low contrast (Figure 1A). If the

bars and the gap are wide enough, and if the eye is reasonably well accommodated to start with, any increase in sharpness of the optical image induced by an effort to see would not have a measurable effect on the brightness difference measured at the center of the gap and the center of each bar. A change in sharpness might affect the border, and it remains to be seen whether this can bring about the improvement in the visibility of the gap which can be demonstrated.

A B

Fig. 1. Stimulus patterns for demonstrating the effect of an effort to see.

The two bar pattern (Figure 1A) is complicated for making an experiment of this sort, because when the gap drops below the threshold of visibility, this involves not only a breakdown of the borders between A and B and C and B, but also the establishment of new borders between D and B and between B and E. In order to keep the problem simple, we might substitute a bright disc on a slightly darker background (Figure 1B) for the gap between two bars.

Fry and Robertson[1] have used a stimulus pattern of this sort having the dimensions shown in Figure 1B. This target was placed at a distance of approximately 1 meter from the eye and was observed by the right eye through a 2 mm. artificial pupil. The left eye was occluded. The black dot at the center of the pattern served as the point of fixation. When the brightness of A is 0.27 c/m^2 and the brightness of B is somewhat greater, the small central disc is intermittently visible. The subject observed for 1 minute periods and recorded the visibility periods on a kymograph drum. The subject tried to fixate the point at the center of the pattern steadily during the periods of observation. During one period the subject attempted to accelerate the rate of fluctuation by hastening both the disappearances and also the reappearances, and in the next period he tried to retard the rate by delaying both reappearances and disappearances. The attempt to hasten a reappearance or to delay a disappearance consisted in paying close attention to the stimulus, whereas the attempt to delay a reappearance or to hasten a disappearance consisted in observing the stimulus passively, merely noting whether the spot was present or absent. Four minutes were allowed for dark adaptation at the beginning of each series of observation periods and two minute intervals between the observation periods.

Measurements were made with the right eye normal and on a subsequent occasion with the right eye paralyzed with homatropine. A —2.00 lens was used in connection with the normal eye so that considerable accommodation was required to focus the stimulus. When the eye was paralyzed, the lens best suited for clear vision was used, +2.00 for Robertson and +0.50 for Fry.

The results of the two subjects are shown in Table I. The values represent averages for three 1-minute periods of observation. When the eye is normal, voluntary changes in attention are shown to change the frequency of reappearances, but this effect disappears when the eye is paralyzed. One may conclude therefore that the effects produced by changing attention are brought about by changes in accommodation.

TABLE I

Effect of Voluntary Changes in Attention Upon the Recurrent Visibility of a Test Object

		Normal			Paralyzed		
Sub.	Attitude	Av. vis. period	Av. inv. period	Av. total cycle	Av. vis. period	Av. inv. period	Av. total cycle
R	Retard	21.70	1.60	23.30	11.62	2.86	14.48
	Accelerate	3.23	2.00	5.23	10.53	2.46	12.99
F	Retard	10.40	7.44	17.84	6.32	3.80	10.12
	Accelerate	3.93	2.31	6.24	6.69	3.44	10.13

Although an artificial pupil was used, and although the size of the test object was selected to make changes in the blurredness of the optical image ineffective so far as contrast is concerned, changes in sharpness of the border were not ruled out.

In order to investigate to what extent this factor is involved, the above experiment was repeated with Fry's right eye paralyzed and thrown out of focus with plus and minus spheres. For each lens a 1-minute record of fluctuations was obtained, and the results are plotted in Figure 2.

The data show that changes in sharpness of the optical image *per se* can actually produce the same effects that are obtained by making an effort to prolong or shorten the visibility and invisibility periods. It is doubtful, therefore, if other factors than sharpness of the retinal image have to be considered.

Fry and Robertson have shown that changes in intraocular pressure produced by changes in accommodation can affect the visibility of an after-image, and in our present state of knowledge, it is logical to suspect that this factor might also be operating in the case of a primary image.

The results considered up to this point indicate that once the ac-

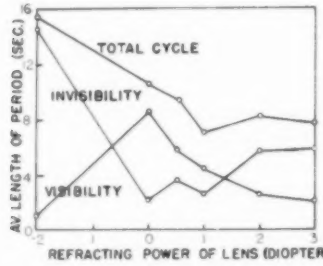

Fig. 2. The effect of sharpness of the retinal image on the intermittent visibility of a low contrast object.

commodative mechanism is paralyzed and fixation is kept steady and an artificial pupil is used, it is not possible to improve acuity by making an effort to see. However, Gregg[2] has recently investigated three myopic subjects who are able to get "flashes" of improvement in visual acuity by making efforts to see even though the eyes are paralyzed with homatropine. Gregg has not been able to discover what factors are responsible for the effect. Gregg demonstrated that closure of the eyelids was not involved, and used both a skiascope and a Scheiner disc to show that changes in accommodation were not taking place.

In one case a myope of about 5 D. showed an improvement from 20/600 to 20/50 during the "flashes." It is difficult to see how such improvement can occur without bringing the eye into better focus. This leads one to believe that some factor can be found in the stimulus pattern or image forming mechanism that is responsible for these anomalous results, but tracking down such a factor will probably be a very tedious operation.

McFadden[3, 4] has carried out an investigation of the effect of practice in making an effort to see. He employed a test object consisting of two vertical black bars with the gap between the bars equal to the width of the bars and with the height of each bar being three times the width. The field of view was limited by letting each eye of the observer look at the field through a pair of artificial pupils, one (2.12 mm. in diameter) placed close to the eye and the other, a little larger, about 10 cm. in front of the first. The angular size of the bars was controlled by moving the target in a fore and aft direction, keeping it centered on a line passing through the midpoint of the base line connecting the two centers of rotation. The observation was binocular, and periodic readjustment of the apertures in front of the eyes was necessary. The brightness of the field was 430 c/m^2. If the target is moved far enough away from

the eyes, the two bars are fused to form a single bar. As the target is brought closer to the eyes, a distance is reached at which the visibility of the gap becomes intermittent, and finally a distance is found at which the intermittency disappears and the bars appear continuously resolved. Figure 3, which is a reproduction of one of McFadden's graphs, shows the effect of training upon the point of first and final resolution. The visual acuity is recorded in terms of the Snellen notation. A value of 1.50 represents a distance of 4.5 meters: a value of 1.00 a distance of 3 meters, and a value of 0.75 a distance of 2.25 meters from the eye. McFadden points out that during the early experimental periods the subject becomes quite fatigued from the efforts to see but after the skill is acquired, seeing with a high degree of efficiency is effortless.

McFadden made no effort to determine the changes in behavior of accommodation throughout the course of experiment. This factor should be investigated by simultaneously determining the state of accommodation or by paralyzing accommodation. One possibility which ought to be investigated is that when the eyes are forced to observe under these conditions they are subject to a tendency toward over-accommodation or functional myopia and the skill acquired is skill in overcoming this tendency. The presumption is that the use of an aperture close to the eye to restrict the field induces an awareness of nearness or some such effect which produces the over-accommodation. Effects of this sort are not unknown. The phenomenon of night myopia is assumed by many investigators to be induced by a reduced level of illumination. Luckiesh and Moss[5] have proposed that accommodative behavior of this sort is induced by the absence of an optical stimulus to accommodation. According to their conception the maximum degree of relaxation of accommodation is not achieved until the eyes are presented with an optical stimulus upon which they can focus.

McFadden called attention to the fact that acuity improves when the other objects are placed on the white field surrounding the black bars. This suggests that the additional objects in the field enable the observer to achieve a greater relaxation of accommodation.

McFadden reasoned that since the range from, say, 2.25 meters to 4.5 meters, which are approximately the distances at which fusion occurs at the beginning and end of training in Figure 3, requires a change in accommodation of about 0.25 D., accommodation could hardly be considered to be a factor in his experiment. In this line of reasoning McFadden has overlooked the fact that the target at 2.25 meters subtends twice the angle that it does at 4.5 meters and hence can be seen with the eye 0.75 D. out of focus. The range from 2.25

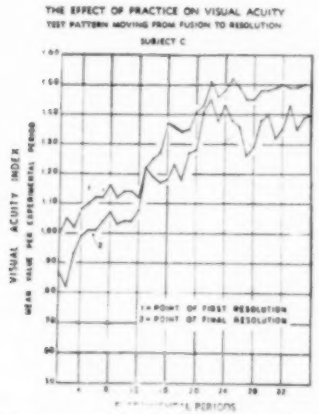
THE EFFECT OF PRACTICE ON VISUAL ACUITY
TEST PATTERN MOVING FROM FUSION TO RESOLUTION
SUBJECT C
VISUAL ACUITY INDEX
MEAN VALUE PER EXPERIMENTAL PERIOD
1 = POINT OF FIRST RESOLUTION
2 = POINT OF FINAL RESOLUTION

Fig. 3. A graph reproduced from McFadden's paper showing the effect of training on visual acuity.

meters to 4.5 meters therefore would correspond to a relaxation of accommodation of about 1.00 D.

A determination of whether changes in accommodation lie at the basis of McFadden's phenomenon should certainly be the next step in analyzing the factors involved.

SUMMARY

Attention has been called to several types of psychological factors that have to be considered in the measurement of visual acuity. The first factor, the interpretation of blurred imagery, presents no problem. The other factors which have been described are associated with "efforts to see" and are more difficult to cope with. For the most part these effects can be attributed to changes in accommodation, pupil size, and intraocular pressure.

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METACONTRAST*

HISTORICAL INTRODUCTION

Mathew Alpern†
College of Optometry, Pacific University
Forest Grove, Oregon

The brightness of a flash of light is considerably reduced when it is followed by a second flash which excites an immediately adjacent retinal region. Such a depressing effect was conclusively demonstrated by Stigler (1910), Baroncz (1911), and independently by Fry (1934a), but evidence for its existence may be found in the much earlier experiments of Sherrington (1897) and of McDougall (1904a).

While complete theoretical ordering of the phenomenon is unachieved, most investigators have assumed that some type of inhibitory activity occurs at a synapse or synapses in the visual pathways beyond the level of the photoreceptor.

This paper will be a historical review of some of the experiments which have been carried out upon the phenomenon of metacontrast. Later papers in this series will be devoted to a description of certain quantitative investigations of the characteristics of the phenomenon and to theoretical speculations ordering the processes involved.

1. PRINCIPAL INVESTIGATIONS

In the course of a group of experiments designed, at least in part, to demonstrate the inadequacy of Helmholtz' notion as to the mechanism subserving marginal contrast, Sherrington (1897) rotated a series of "contrast discs" two of which are illustrated in Figure 1. Since the relative proportion of black to white on any circle concentric to the center of the disc is the same (1:1), one might expect that the liminal angular speed necessary to eliminate flicker would be the same for all regions of the disc. This is not the case. For example, when the disc in Figure 1a is rotated counterclockwise, ring-bands corresponding with the white notches and black teeth are seen continuing to flicker at an angular velocity at which the remainder of the disc appears homogeneously gray. When the direction of rotation is reversed, a flickering ring-band persists in the region of the white space between the two black teeth at an angular speed of the disc at which the remainder of

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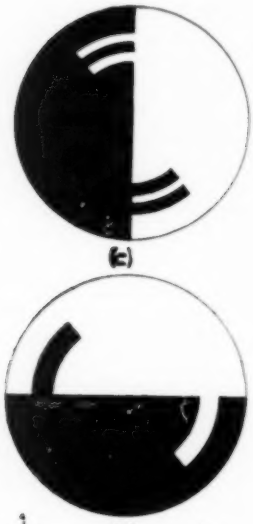
†Optometrist, Ph.D., Member of faculty, Fellow, American Academy of Optometry.



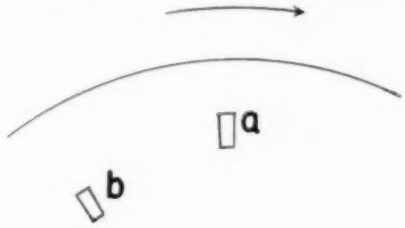
1.

the disc appears homogeneously gray. When the disc illustrated in Figure 1b is rotated clockwise, a flickering ring-band persists in the region of the tooth and notch at an angular velocity at which no trace of flicker is visible elsewhere on the disc. When the direction of rotation of this disc is reversed, flicker for all regions of the disc disappears at about the same speed.

Sherrington explained these phenomena on the basis of "simultaneous contrast," i.e., the white region surrounding the black teeth tends to make the black teeth appear blacker than the remainder of the black region of the disc, and the white notches surrounded by black appear whiter than the white of the remainder of the disc. Hence, the "whitest" white sector and the "blackest" black sector having the same radius would continue to flicker at frequencies of alternation which cause the disc elsewhere to appear homogeneous. Such an explanation is subject to at least two serious objections: (1) No very marked simultaneous contrast effect is visible on the black teeth and the white notches when the disc is stationary. Consequently, the rotation of the disc itself must be contributing to the effect. (2) The region of the disc in which flicker persists at the higher angular velocity is a function of the direction of rotation of the disc.

In order to meet this second objection Sherrington assumed that the "intensified" black would have less effect when it followed a period of black than when it followed a period of white. Similarly the "intensified" white would have a greater effect when it followed a period of black than when it followed a period of "unintensified" white.

While studying the time course of a sensory impression produced by a momentary photic excitation of the retina, McDougall (1904a) performed the following experiments: Two radial slits *a* and *b* three degrees wide and one centimeter long were arranged in a disc at an angular interval of 30 degrees in such a way that the path of the one slit was immediately outside of the path of the other (Figure 2). When



2.

one of the slits, *b*, was covered, rotation of the disc before a luminous ground glass with an angular velocity of approximately one revolution per second revealed (under controlled fixation) a pattern of alternating dark and light bands described in detail by Charpentier. This pattern was followed by a dark interval which in turn was terminated by the appearance of "Bidwell's ghost," a grayish band spread out as an arc on the circumference of the disc. Following the termination of the "ghost" and a second dark interval a broad train, the secondary image, appeared. McDougall believed the "Bidwell's ghost" to be merely the terminal part of the "primary" response and attributed to the rods the predominant role in its production. The dark interval separating the "Bidwell's ghost" from the Charpentier bands was consequently regarded as a

manifestation of the inhibition of part of the "primary" image by the leading edge of this image. That is, the more recent part of the response inhibited the earlier part of the response in an immediately adjacent region of the retina. To demonstrate that the "ghost" could be inhibited McDougall uncovered slit *b* and rotated the disc in the direction of the arrow (Figure 2). There was an inhibition thereby of the "ghost" following *a* while that following *b* persisted. When the direction of rotation was reversed the opposite result was obtained.

A few years later Stigler (1910, 1913, 1914, 1918, 1926) described a series of experiments which are related to the experiments described by Sherrington and by McDougall, although Stigler either was unaware of these previous works or did not realize their relation to the phenomenon that he reported. Two semi-circular photometric surfaces were arranged in such a way that their borders were contiguous and so that when they were exposed simultaneously they appeared to form a circle when they were viewed monocularly with a natural pupil. If the left half of the white circle on a black background was exposed for a duration less than the action time (McDougall, 1904b) and after its disappearance the right half was exposed for the same duration, a very strange phenomenon was observed. Stigler (1913) described it as follows:

> Almost nothing of the first exposed semi-circle is seen except a thin sickle-shaped border at its periphery, while the larger middle part remains black. The second-exposed right semi-circle appears entirely white, only just a little darkened.

The same result was obtained with increased or decreased size of the two photometric fields and also when the surfaces were rectangular or elliptical in shape.

Stigler (1910) designated the part of the *Primärempfindung* which occurs during excitation as to the homophotic image and that part which occurs after the cessation of the excitation as the metaphotic image. Consequently he called the depressing effect occurring after the cessation of the excitation *metaphotische Kontraste* or simply *Metakontrast*, in order to differentiate it from *homophotische Kontraste*, or simultaneous marginal contrast as the term is usually understood. Pieron (1935a) has criticized this terminology on the basis that in the case of flashes of duration less than the action time no "homophotic" image occurs since the sensory impressions appears an appreciable time after the cessation of the excitation. The term metacontrast has persisted, however, but in present usage refers specifically to the depression effect of the second of two brief adjacent asynchronous excitations on the sensory impression produced by the first.

On the basis of qualitative observation Stigler noted that not only

did the second flash inhibit the first but that the first also inhibited the second. He demonstrated this by observing that the second flash appeared darker when it was preceded by the first than when it appeared alone. This depression effect of the first of two flashes on the second he called *Parakontraste*.

Stigler (1910) demonstrated that when the adjacent edges of the two photometric fields were separated by a distance of 1.9 millimeters (13 minutes) the metacontrast effect disappeared, in spite of the fact that the extent of the darkening of the photometer surface exposed first was considerably greater than this when the two surfaces were contiguous.

The metacontrast effect was found to increase as the luminance of the surfaces increased although only qualitative judgments on the amount of metacontrast were possible. No statement as to the absolute values of the luminances of the surfaces was given.

The persistence of the bright sickle-shaped border on the edge of the field irrespective of the size of the fields undergoing metacontrast was explained on the basis of an active *Weissinduktion* produced by the black background.

The following hypothesis was advanced by Stigler (1913) to explain the depressing effect of a subsequent excitation on a preceding one:

> The visual stimulus starting from the left (i.e. the first exposed) semicircle, has to pass on its way from the retina to the visual centre a series of ganglia, in which it has to produce some change, similar to the Bahnung (clearing of the way), so that the stimulus will be retarded from running to the centre. During its retardation in these ganglia the neighbouring-stimulus, produced by the right semicircle, arrives and produces a "metacontrast" effect upon the ganglia first stimulated, so that their stimulation ceases.

In analyzing Stigler's experiments it is important to bear in mind that each judgment represents only a comparison of the relative effect of the depression of the second surface by the first (paracontrast) to the depression of the first surface by the second (metacontrast).

In 1911 Baroncz demonstrated metacontrast in a somewhat different way. He used a vertical rectangular white screen (I) 14x28 cm. observed in a completely dark field. In the center of this screen a gray screen (II) was visible through a square window 1 cm. on each side. A similar window which also permitted vision of screen II was placed in the dark field with its center 14 cm. from the first window and on a horizontal line with the center of the first window. With suitable shutter arrangement it was possible to illuminate the two screens independently with asynchronous flashes. The entire field was viewed with indirect vision, binocularly with natural pupils at a distance of 1.4 meters.

Baroncz found that in the case of exposure of the background prior to the two squares, the square within the white surround looked slightly darker than the square with the dark surround. If the squares were exposed prior to the white rectangle, the square which appeared on the white rectangle was again darker than that on the black background.

As in Stigler's experiments the estimation of the amount of depression in these experiments was purely qualitative. Unlike Stigler, however, Baroncz was able to separate the effect of the second exposure on the first from that of the first on the second and found that the former was much greater than the latter.

With regard to the effect of increased temporal separation and duration of the exposure on the magnitude of these depression effects, Baroncz states:

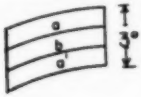
> . . . Je länger innerhalb gewisser Grenzen die Beleuchtung der umschliessenden Felder and je länger bis zu einem gewissen Grade die Pause dauert, desto deutlicher ist die Kontrasterscheinung. Eine Grenzpause lässt sich hier auch nicht mit Genauigkeit bestimmen. Sie ist, wie mir scheint, in der ersten Gruppe (i.e. paracontrast) kürzer als in der zweiten.

Baroncz also demonstrated the effects of metacontrast and paracontrast in a manner somewhat similar to the method later used by Fry (1934a). The square surrounded by the white background was made equal in brightness to the background. The square was then exposed prior to its background with a dark pause separating the exposure of the two. The square appeared darker than the background. When the procedure was reversed the square appeared brighter than the background. Both of these latter experiments again demonstrate the predominance of metacontrast over paracontrast even when the surface producing the latter is much larger than that producing the former, all other factors remaining constant.

In both Stigler's and Baroncz' experiments use of a natural pupil would tend to complicate the results obtained with the experiments on paracontrast. These effects would, of course magnify the paracontrast effect (and in Stigler's experiments reduce, thereby, the metacontrast effect). Since, however, the reaction time of the pupil is quite large (0.2" approximately according to Löwenstein and Friedman, 1942) relative to the time intervals involved in the majority of these experiments, this becomes important only in the experiments involving extremely long time intervals.

The depression produced by metacontrast was demonstrated, again by Fry (1934a), who was unaware of the previous experiments of Stigler and Baroncz. Fry used slits in a disc rotating before a small luminous window so arranged that the field exposed first was strictly adja-

cent to the field exposed second. The stimulus pattern is illustrated in Figure 3. By using extremely short exposures (4 to 1.12 msec.) the three



3.

patches of light a, a', and b produced sensory impressions which appeared simultaneously, although a and a' (always flashed together) were exposed at some finite interval (5 to 150 msec.) before or after b. When both a-a' and b were exposed for the same duration the second exposed field appeared brighter than the first and by varying the duration of the second it was possible to reduce the energy (intensity x time) from the latter so that the three contiguous fields appeared homogeneously bright. The duration of the second exposed field then gave a quantitative measure of the magnitude of the effect. That the first had been depressed by the second and that the first did not affect the second was demonstrated in the following way: A third homogeneous surface c of the same form and area as b plus a-a' (which had been matched) followed the exposure of the latter 1.25" later. The duration of c was then varied until it matched b and a-a' and this was found to be of the same order of magnitude as the duration of the second exposure.

Although Fry's method of successive comparisons is admittedly coarse, the conclusion that the effect is one of depression rather than enhancement cannot be questioned. This was demonstrated by Fry, himself, who showed that the effect was greater when a-a' followed b than when a-a' preceded b. Fry performed all these experiments monocularly using an artificial (2 millimeter) pupil to avoid any extraneous effect produced by changes in the pupil size at the longer time intervals.

The magnitude of the net depressing effect was found to increase as the duration of the time interval between the two exposures increased up to 0.15 sec. although quantitative measurements were not possible at this latter value because it was impossible to make the duration of the second stimulus short enough to obtain a match. When the duration of the interval between the two exposures was prolonged beyond 0.15 sec. measurements were no longer possible because of the perception of apparent movement between the fields (phi phenomenon) which occurred because of the magnitude of the asynchrony of the exposures.

By keeping the intensity of a-a' and b fixed and equal and by vary-

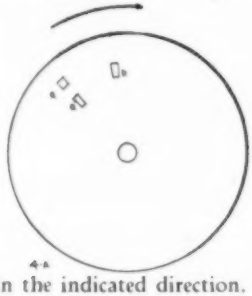
ing the duration of the field exposed first, or conversely, by varying the intensity of both fields and keeping the duration of the field exposed first fixed, it was possible to determine the effect of increased energy of the first exposure on the magnitude of the net depressing effect. The results obtained by the two methods were identical (thereby verifying the basic assumption that the duration of the exposures were within the limits of the so-called reciprocity law, i.e. intensity x time = constant). The magnitude of the net depressing effect was found to increase as the energy of the field exposed first increased.

Fry also attempted to determine the spatial limits within which these effects would continue to operate. To do this the separation of the adjacent edges of *a*-*a'* and *b* was gradually increased. Increase of this separation was accompanied by a gradual reduction in the magnitude of the net depressing effect until at an angular separation of 1°14' the effect had completely disappeared.

Although Fry was unaware of Stigler's work he advanced a hypothesis to explain the effect which was quite similar to that proposed previously by Stigler. Fry explained his results on the principle:

> . . . that the response of the retina to the first stimulus is considerably delayed and prolonged and overlaps in time the response to the second stimulus and is inhibited by it by some kind of interaction between retinocortical pathways at synapses either at the retina, or at the basal ganglia, or at the cortex.

The procedure employed by Fry was modified somewhat by Pieron (1935a) in order to elicit further facts concerning the nature of metacontrast. Using luminous slits on a rotating disc or white patches on a black rotating kymograph drum Pieron demonstrated that the first exposed flash could be so depressed that it appeared virtually invisible. If a disc similar to the one illustrated in Figure (4a) was rotated at a



4a

slow angular velocity in the indicated direction, each of the three luminous slits gave rise to the "ghost-like" train of images spread out as arcs on the surface of the disc which was described in detail by McDougall (1904a). However, in accordance with McDougall's findings, the

angular length of the train produced by *b* was shorter than that of the trains produced by *a* and *a'*.

Since metacontrast appears here to involve a depressing effect on the tail end of the train of images following in the path of the luminous slit on a rotating disc it seems logical to expect that the depression of the analogue of the tail end of this train in a stationary flash makes a substantial contribution to the reduction of the overall brightness of the flash. It is possible that metacontrast also involves the initial part of the response produced by a brief stimulus. This aspect of the problem will be considered later.

As Pieron increased the angular velocity of the disc in Figure (4a) slightly, (the absolute values are not given in the published paper) the bright trains produced by *a* and *a'* formed complete annuli, with the successive trains in each band merging to form a uniform flickering ring. Essentially the same thing occurred in the case of the middle band except that it appeared much darker.

Increase of the angular velocity still more caused the middle ring to increase in brightness until the three rings were equally bright.

A determination was then made of the liminal angular velocity required to make each of the three rings appear without flicker and it was found that the c.f.f. was measurably lower for the rings produced by *a* and *a'* than it was for the ring produced by *b*. In this series of experiments Pieron demonstrated the gradual transition from metacontrast effects with pairs of flashes to metacontrast effects with intermittent stimuli, such as were originally demonstrated by Sherrington.

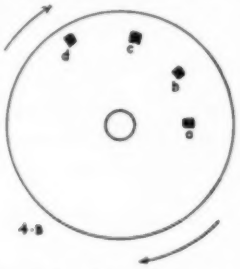
Analogous phenomena have been demonstrated by Fry (1935) with a continuously luminous surround, and a light-dark ratio of 1 to 5. When the flashes were presented at a frequency of 2 to 4 cycles per second, bright flashes were seen superimposed on a dark background. At six cycles per second the flashes seemed to disappear and what constituted the dark background for the flashes emerged into a uniform dark flickering patch to which a single brightness value could be assigned. Fry found it to be 1/5 of the Talbot brightness. This implies that the entire flash of light and not just the tail end of the response may be subject to inhibition.

When the frequency was increased the brightness of the flickering light gradually increased and approached its Talbot brightness, which is the brightness of an intermittent stimulus above its critical flicker frequency.

That a continuously luminous surround causes the c.f.f. of a flickering light to increase also, has been adequately demonstrated by Lyth-

goe and Tansley (1929), Graham and Granit (1931), Geldard (1934) and Fry and Bartley (1936). There is a possible relationship between this phenomenon and that described by Sherrington. Fry and Bartley suggest that the surround acts to depress the less active phase of intermittent activity, rather than to enhance the more active phase as the earlier investigators supposed.

When Pieron rotated a disc similar to the one illustrated in Figure 4b before a luminous diffusing glass surface at a moderate angular velocity



in the indicated direction only three rings appeared. The inner ring produced by *a* had been completely inhibited, the ring produced by *b* was very dim, that produced by *c* brighter, while only the ring produced by *d* appeared without the trace of inhibition, being longest and most luminous. Reversing the direction of rotation produced the opposite effect. This demonstrates the cumulative effects of several stimuli producing metacontrast and also that the inhibition of the second of three stimuli by the third does not reduce the ability of the second to inhibit the first.

Increasing the luminance of the inhibiting surfaces with respect to that of the inhibited surface was found to increase the magnitude of the metacontrast effect.

In order to explain the phenomenon of metacontrast Pieron (1935b) elaborated on the hypothesis advance by Stigler and by Fry in the following way:

> . . . Le train d' influx nerveux déclenché par l' impression lumineuse initial (et qui est de longue durée, comme l'oscillographie des potentiels d'action l'a montré dans le nerf optique) est inhibé quand un nouveau train d'influx est declénché dans une région rétinienne adjacente, par un second éclat, lumineux: La queque du premier train étant ainsi coupeé, il en résulte un raccourcissement notable de l' impression lumineuse initials, reccourcissement qui fragilise cette impression, et permet son inhibition complète dans la structuration perceptive qui s'effectue au niveau de l'écorce.

In a series of experiments demonstrating both facilitation and inhibition in the visual mechanism Bogoslowski and Segal (1945, 1946) and Baumgardt and Segal (1946, 1942) performed some further

experiments relating to metacontrast. The arrangement of the apparatus was similar to that of Stigler's in that the two asynchronously exposed surfaces were contiguous semicircles (with radii of 5°). Measurements of the effect were made in a manner similar to that of Stigler and the criticisms of this methodology pointed out above are also applicable here.

In Table I are presented the data of a series of experiments from the published paper (Baumgardt and Segal, 1942).

TABLE I

	1.4 c/m²	14 c/m²	140 c/m²	1,400 c/m²
First appearance of inhibition	33	17.5	5	5
Maximum of inhibition	80	77	89	56.5
Limit of retroactive influence	144	138	192	120

The luminance values in Table I represent values of both surfaces. The two surfaces were exposed 18 msec. each and the values in the table represent the time interval (in milliseconds) between the onset of the two stimuli. The criterion for the appearance of metacontrast was the presence of a dark band on the surface exposed first. The criterion for the maximum was the appearance of the widest "band of inhibition." The limit was determined as the time interval for which the surface exposed first appeared without the "band of inhibition."

Baumgardt and Segal proposed a general hypothesis to explain the various phenomena of facilitation and inhibition which they studied. This hypothesis involved the integration in the cortical cells (the esthesioneurones) of a series of direct impulses and "polysynaptic waves" similar to those demonstrated by Lorente de No (1938) in the oculomotor nucleus of the rabbit. With regard to the inhibitory effect of a second exposed surface on its immediately preceding neighbor (i.e., metacontrast) Baumgardt and Segal describe the hypothesis as follows (1946e):

> . . . La première plage recoit une volée d'influx directs et en plus le bombardement des influx polysynaptiques déclenchés par les premiers. L'allumage de la seconde plage fournit à la première un supplément d'influx polysynaptiques sans ajouter d'influx directs. La forte inhibition observée . . . semble indiquer que l'action inhibitrice des ondes polysynaptiques est diminuée en présence d'un apport simultané d'influx directs: ceci indiquerait que ces derniers ont toujours un rôle excitant.

In another experiment Baumgardt and Segal (1946e, 1942) exposed one of the surfaces continuously and flashed the other for brief periods. The flashing surface revealed the typical inhibitory band.

These experiments appear to be related to the experiments of Fry (1935) discussed above which demonstrated the effect of bright surround upon the brightness of an intermittently flashing surface.

The fact that the depressing effect continues to be manifest when the

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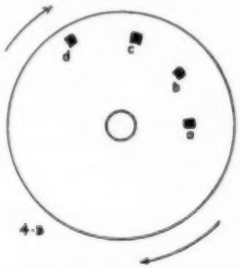

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These experiments appear to be related to the experiments of Fry (1935) discussed above which demonstrated the effect of bright surround upon the brightness of an intermittently flashing surface.

The fact that the depressing effect continues to be manifest when the

inhibiting surface is exposed constantly would seem to imply that the effect of continuously illuminated surround on the c.f.f. observed by Lythgoe and Tansley (1929), Graham and Granit (1931), Geldard (1934), and Fry and Bartley (1936) may be related to metacontrast.

The increase of the c.f.f. as a function of the size of the retinal area stimulated reported by Granit and Harper (1930) and others also may have some relation to metacontrast. The effect considered in this way does not represent a summation as Granit and Harper suggest but a depression of the less active phase of the intermittent activity mediated by the stimulation of the retinal region excited by increase of the area of the flickering surface.

The fact that a continuously illuminated surround has an effect on the brightness of a brief flash of light is of some importance in the consideration of a large group of experiments on the Broca-Sulzer phenomenon. Broca and Sulzer (1904) studied the effect of duration of exposure on the brightnesses of equally luminant flashes. The curve representing the brightness of various flashes as a function of their duration rises to a maximum (termed the action time by McDougall, 1904b) and then sinks to an intermediate level. To obtain this curve Broca and Sulzer maintained one standard field continuously exposed while an adjacent field was flashed at various brief exposures: the brightness of the brief flash was matched by variation of the luminance of the standard field. The Broca-Sulzer experiment has been repeated a great number of times and the early experiments have been critically reviewed by Bills (1920). Such experiments are, of course, subject to the criticism first pointed out by McDougall (1904b) that the illumination of the surround effects an inhibition upon the briefly exposed field which may vary for various durations of the exposure of the flash.*

2. INCIDENTAL OBSERVATIONS

Depressing effects of photic excitation which have some of the characteristics of metacontrast occasionally have been reported in the literature as more or less incidental observations in the course of experiments on other phases of visual perception.

Werner (1937) in a series of experiments on contour formation exposed a solid black disc on a light background for a brief period and, after 150 msec. he exposed a black ring (whose inner border coincided with the outer edge of the previously exposed disc) on a light back-

*Several experiments have been performed on this phenomenon which are not subject to this criticism. Bills (1920), McDougall (1940b), but these experiments did not trace out the course of the curve in detail. The more recent experiments of Stainton (1928) are subject to the original criticism of McDougall.

ground. Under suitable conditions the disc was not seen at all and in certain cases the enclosed field appeared brighter than the surround. This latter phenomenon seems to be an example of a metacontrast inhibition although the matter cannot be decided conclusively since no attempt was made to study its characteristics in detail.

An effect of a subsequently exposed surround in raising the absolute threshold of a flash of light was demonstrated by Crawford (1947) in the course of an extensive series of experiments on adaption. A 12° circular conditioning stimulus was exposed for 524 msec. at various intervals following the exposure for 10 msec. of a 0.5° concentric test stimulus. The absolute threshold for the test stimulus was determined *for central fixation* at each interval between the onset of the test stimulus and the onset of the surround. When the surround stimulus followed the test stimulus at intervals greater than 100 msec. no effect on the absolute threshold of the test stimulus was obtained. As this temporal interval was gradually reduced below 100 msec. the threshold of the test stimulus showed a progressive rise reaching a maximum value (an increase of 2 long units) when the temporal interval was reduced to zero.

3. CHROMATIC METACONTRAST

Shortly after Stigler published his first paper on metacontrast Baroncz (1911) observed metacontrast effects for chromatic stimuli. He exposed a white light for 7.2 msec. and after a pause of 72 msec. a red light was exposed (also for 7.2 msec.) to the surround. A dark green shadow appeared in the region stimulated by the white light. This effect disappeared when the interval between the two exposures was prolonged to 96 msec.

Pieron (1935a) produced evidence which is exactly contradictory to that of Baroncz. By rotating a black disc with a white slit followed by two surrounding colored slits no "contrast" color could be produced on the white zone irrespective of the time constants or dominant wave lengths of the stimuli, although a clear depression of the white zone was observed. The same results were obtained if the surrounded zone was colored and the surrounding zone was white or if complementary colors were used in the two regions. The discrepancy between the results obtained by Baroncz and those of Pieron can probably be attributed to differences in the stimulus conditions, but this could not be decided from the published papers.

A series of experiments which may be physiologically related to chromatic metacontrast, although they are not obvious manifestations of it, were reported by Fry (1933a, 1933b, 1935, 1936). These ex-

periments relate to the color sensations produced by intermittent white stimulation. Fry (1935) demonstrated that such color sensations are not explicable on the basis of a three component theory of color vision but fall in accord with the notion of the frequency modulation theory of color vision, which was first suggested by Troland (1921) and later elaborated in some detail by Fry (1945).

Fry's experiments included the effect of luminous surrounds exposed both intermittently and continuously on the hue of an intermittent test field. As long as the test field is exposed intermittently within a certain range of frequencies the subjective colors can be induced into it. The precise nature of these effects and their relationship to metacontrast must await further experimentation.

Fry (1934a) studied the metacontrast effect of the various spectrally pure colors. Illuminating both the first exposed and the second exposed surfaces with the same wave length he determined the relative depressive effects of the various wave lengths for the same retinal illuminance (1825 photons) by determining the duration of the second exposed surface required to match the first (exposed for 4 msec.) at every 20 millimicra from 440 to 680 millimicra. This duration proved to be 1.8 msec. for all wave-lengths.

4. BINOCULAR METACONTRAST

The question as to whether metacontrast could be produced when the first exposed field was observed by one eye and the second exposed field by a correspondingly adjacent region of the other eye was recognized by Stigler as being of theoretical importance.

In his early experiments Stigler (1910, 1913, 1914, 1918) was unable to demonstrate any binocular metacontrast effects. However, in a later paper (Stigler, 1926) he goes into a great detail to describe the apparatus by means of which such effects may be obtained and he subsequently (Stigler, 1935) insisted that he was successful in obtaining them. However, at no time does he describe the appearance of the phenomenon, give any quantitative data, or indicate the reasons for the discrepancies between the earlier and subsequent results.

Baumgardt and Segal (1946f, 1942) attempted to obtain binocular metacontrast but under the conditions in which metacontrast usually occurred they were unsuccessful. They then reasoned that, if the level of monocular metacontrast was different from that of binocular metacontrast, the time constants of the two phenomena would be different. The problem then became one of finding the proper constants. Accordingly they found (1942):

. . . L'expérience confirme la prévision. Dans les condition indiquées, avec deux stimuli de 30 ms. et un intervalle de 80 ms. on réalise par fusion binoculaire un

métacontraste sinon très fort, tant au moins trés nettement perceptible. La diminution de la brillance apparente de la plage no. 1. peut être evaluée à 50% de celle de la plage no. 2.

5. SUMMARY

The depression of the activity aroused by a flash of light by a subsequent excitation of the immediately adjacent retinal region may serve to maintain the quality of the sensory impression produced by a light moving across the visual field. It may do this by removing the tail end of the train of images following a moving slit. It is as though one writes across the chalkboard with a piece of chalk in one hand and an eraser following the chalk in the other. In the case of the cinema, metacontrast might presumably make it possible for each frame to wash out the effects persisting from the last frame in addition to registering its own impression. It may also function similarly in connection with saccadic and pursuit movements of the eyes.

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VISUAL ACUITY UNDER SPECIAL CIRCUMSTANCES*

Ernest J. Giglio†
School of Optometry, Columbia University
New York, New York

This is a preliminary report and is offered prematurely because of the implications for anyone who undertakes to measure visual acuity.

It has been noted clinically that occasionally a myope not wearing his distance correction will exhibit an ability to read letters on the test chart quite out of proportion with his error of refraction as noted objectively, or with his subjectively determined prescription. Some myopes have undergone "training" for improvement of visual acuity without glasses and have expressed satisfaction with the results, and several studies[1, 2] have indicated mediocre, if not negative, results. Many individual cases have been reported where the order of magnitude of changes are from 20/200 to 20/20 or 20/30. Still, very often when these same patients were re-examined by critical observers, it was reported that no change, or very little change, in the acuity had taken place as compared to the original findings. These small increments of improved ability to read a test chart have been explained on the bases of "practice effect," or "increased ability to interpret blur circles." In addition, the writings and training programs of such people as Bates,[3] Huxley,[4] and Peppard[5] have obviously produced sufficient results, which, at least in the minds of their followers, justify continuing their practices from 1920 to the present.

With the foregoing as a background, the writer was asked to examine several myopes who were said to be able to exhibit unusual acuity. The suggestion was made that the conditions under which these people could perform were tenuous and several visits might be necessary before they would perform as reported. The following is a review of a case which is atypical only for the amount of the myopia.

W. L. Age 19. College Student.

Present Rx.

O.D. — 8.00 —0.75 x 75
O.S. — 8.00 —0.75 x 90 V.A. = 20/30—.

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†Optometrist. M. S. Ed. Member of faculty. Fellow, American Academy of Optometry.

Static Ret.
O.D. —10.00 —0.50 x 85
O.S. — 9.50 —0.75 x 85
Subjective
O.D. — 9.00 —0.75 x 75 V.A. = 20/25+.
O.S. — 9.00 —0.75 x 90 V.A. = 20/25+.
Phoria at distance with Rx. 4.5 exophoria.
Phoria at near with Rx. 2. exophoria.
Dynamic X-cyl.

(unfused)	O.D. add +0.75	O.S. add —0.25 (?)	}	3 exo.
(fused)	O.D. add +1.00	O.S. add 0.00	}	

This patient has had glasses since he was nine years of age. However, they were worn principally for reading. Glasses were worn very little outdoors. Tennis and baseball were played without glasses. This patient received no previous training for visual improvement and described intervals of clear vision to the referring doctor on his first visit.

It required three visits before the patient demonstrated his ability to read 20/25 letters on a distance test chart without glasses. If the phenomenon was tenuous, it was important to observe it before adding devices to insure that the response was neither an artifact nor an unreliable report on the part of the patient. Artificial pupils, tachistoscopes to flash individual letters, and Landolt broken circle charts were on hand; but before these more obvious safeguards were used, the patient was asked to make several apparently innocuous observations. Two small spots of lights were projected on a screen at the same time. One subtended 5′ of arc at the six meter distance, the other was a 30′ spot. The patient was directed to look at the screen,* and when his glasses were removed, he was asked to compare the spots with his blurred vision. The spots appeared about the same size, but one was reported as being much brighter than the other. The reported apparent size was 36.5 cm. at six meters.

This information sheds some light on the reliability of the patient's response and upon his refractive status. The patient's pupil size in the dimly illuminated examining room was about 6 mm. as measured with a P.D. rule. If 10 D. of axial myopia and Gullstrand's constants are assumed, the apparent size of the source can be calculated. Referring to Figure 1, R represents the far point of the myopic eye 10 cm. away from the first principal point H. The scale of the drawing necessitated including a break as shown. The points N′ and F′ are the secondary nodal

*W. L. observed the difference in size of the spots before removing his glasses. This observation helped check the validity of the patient's response.

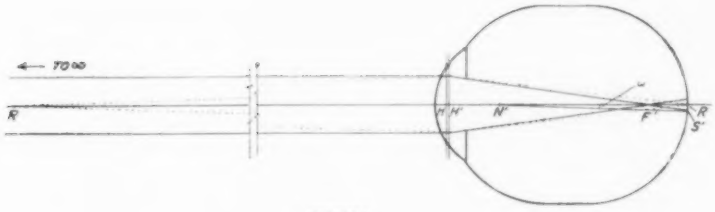


FIGURE I

and focal points respectively for Gullstrand's schematic eye, and R′ the conjugate of R at the retina. The aperture is drawn to approximate a six millimeter pupil, and the point S′ indicates one edge of the blur circle formed by the distant light source. Using the abscissa relation referred to the principal points (U′ = U + F) and Gullstrand's constants

$$\frac{1.336}{H'R'} = \frac{1}{-.1} + 58.64 = 48.64$$

$$H'R' = \frac{1.336}{48.64} = .0275 \text{ M. or } 27.5 \text{ mm.}$$

now $H'F' = f' = 22.8$ mm.

$F'R' = 27.5 - 22.8 = 4.7$ mm.

$$\frac{R'S'}{3} = \frac{4.7}{22.8} \qquad R'S' = .618 \text{ mm.}$$

$$\tan. \omega = \frac{.618}{17.05 + 4.7} = .0284$$

$$\text{at 6 meters } .0284 = \frac{x}{600}$$

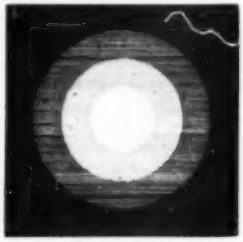
$x = 17.04$ cm.

Since ω accounts for only one-half of the pupil aperture the apparent size of the blurred source becomes 34.08 cm. and compares favorably with the 36.5 cm. reported by the patient. As to the brightness, each source had approximately the same brightness, 3.6 and 3.8 foot candles. Since they have been considered as point sources, they differed only in the amount of luminous flux emanating from each. The larger giving off the greater amount of light and producing the brighter image.

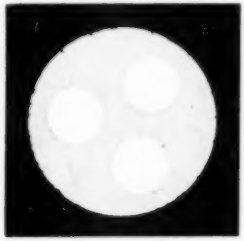
When a 20/40 letter was projected in a ½° square aperture, and the letter was reported as being seen clearly: it was also reported as being multiple. Another early observation the patient was asked to

make consisted in viewing a ¼° bright square projected on a screen in a darkened room. During an interval of clear vision the patient reported several bright squares inside the original blurred area which was now slightly reduced in size. When a ¼° black square was projected on a bright background the patient failed to see it. Said he, "I cannot find it." The patient reported that clearing occurs more easily for small objects than for large ones.

W. L. was asked to make some drawings. Six drawings were made by the patient at home from sketches produced in the laboratory.



Drawing 1

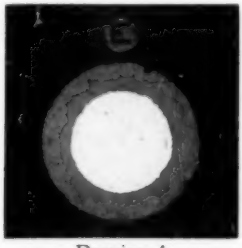


Drawing 2

Drawing #1—9 cm. spot of light seen from a distance of 6 meters. Without glasses and without an interval of clear vision the spot appeared to be about 30 cm. in diameter.

Drawing #2—Patient fixing a 3.5 cm. spot at 6 m. without glasses but during an interval of clear vision. The spot appeared to be 11 cm. in diameter.

Drawing 3

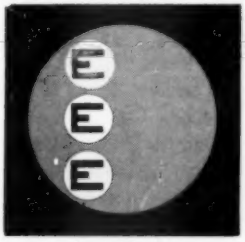


Drawing 4

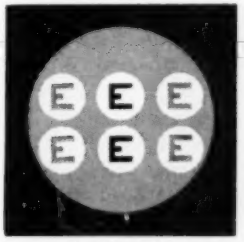
Drawing #3—9 cm. spot at 6 meters with a 20/80 E in the center. Observation made without glasses and without clearing. Patient described the whole blur circle as having two sections. The edge section darker than the center. Each section was a fairly even gray.

Drawing #4—Same as above except that occasionally a shadowy E

appeared above and outside the blur circle. The E was barely visible and showed a "with" motion as the patient shifted his body.



Drawing 5



Drawing 6

Drawing #5—Same 9 cm. spot with a 20/80 E. Observation made at 6 meters without glasses during an interval of clear vision.

Drawing #6—Same conditions as #5 except that during this interval of clear vision 6 images were reported. These being two horizontal rows of three E's each, the two center E's being the clearer, the outer four E's being quite indistinct or faint, being barely perceptible.

The cleared image or images seen inside the blur circle by the myope are subjectively smaller and less bright than the original target (some of the light being dissipated in the blur circle and the less distinct images). It has not been possible to date to make any better measure of these observations. The blurred field in which the image or images are seen decrease slightly in size during the interval of clear vision. This may be the effect of a change in pupil size at this time but the change in the blur circle size is slight enough to make it difficult to see any change in pupil size from direct observation. When the images are multiple, and this is the rule rather than the exception, they invariably arrange themselves in a simple geometric pattern such as a straight line, a triangle, etc. However, these patterns are not necessarily centered with respect to the blurred field in which they are seen. The images float and finally disappear into the edge of the blurred field. They can be fixated centrally and there is little change in either brightness or clarity when a +2 D. or —2 D. lens is interposed. Thus indicating a great depth of field and a small aperture in the system producing them. The number of images discerned seems to decrease with increase in general illumination; and the blurred field in which they are seen also tends to disappear as general illumination is increased.

"Actually," the patient reports, "I do it, (clearing), best of all

outdoors. There is no pain under those circumstances. When I try to do it in the lab here, it is often accompanied by pain and burning." Patient reports an inability to "clear" at near. "As I put the book farther away it becomes easier." As to the area of clear vision, "sometimes the whole field is clear, at other times just a tiny area is clear." "In the laboratory a letter chart is blurred except for the letter being read. This happens when the lights are out and the room dark. With the room illuminated the whole line can be read. Outdoors a billboard can be read normally—the whole thing is clear. If the day is clear I can blink once and the billboard is just as clear as with my glasses. A person half a block away has the same quality, but when the person comes within eight feet only parts are clear." The patient claims that things that are relatively near are clear in only a "single plane at a time." "First the tip of the nose and then backward—the eyebrow, eyelashes, and finally the eye." "After reading or doing close work for half an hour, clearing at distance occurs involuntarily." Another situation where the patient clears involuntarily is coming out of the water during swimming. The patient was questioned further concerning the depth of field during the interval of clear vision. Said the patient, "It is very, very slight and of course much smaller for short distances. At two or three feet it is only an inch or so. This fact curtails their utility to some extent." It was reported that when clearing is obtained on a voluntary basis it is very fatiguing and the patient becomes nervous and irritable. "Sometimes it is easier," the patient reports, "to clear with a reduced correction than without any glasses at all." This technique is used to copy home assignments from the board when written too small for direct resolution. The patient normally has comfortable vision with his correction. He notes that his uncorrected vision seems to change a good deal from day to day.

Some of the responses reminded the writer somewhat of reports of observations on entoptic phenomena. Helmholtz,[6] in his consideration of entoptic phenomena, points out that corneal droplets are a source of entoptic images under certain circumstances. "The bright spot in the middle of each droplet seems to be an imperfect optical image of the source of light; for example, if the light comes through a triangular opening, the bright spot is triangular. This image appears erect in the entoptic field while it must be inverted on the retina." Tscherning,[7] Duke-Elder,[8] and Adler,[9] make similar reports.

Since the observations of the patient bore some resemblance to entoptic phenomena, and since entoptic observations are enhanced by making the eye artificially myopic, it might be possible to produce

similar performances of ability to read test charts with normal subjects made highly myopic with plus lenses. This can be easily verified by projecting a single letter in a small patch of light. A ½° spot containing a 20/60 letter provides an easy target for an emetrope wearing a pair of +8.00 D. lenses. The actual frequency with which normal subjects made artificially myopic can clear a specific target is currently under investigation.

It was further reasoned that if this phenomenon was due to changes in the front surface of the cornea, it might be possible to observe some sort of change in the image of a target seen by reflection from the front surface. By arranging a plate of glass at a 45° angle between the patient and the tube of a B. & L. Keratometer, it was possible for the patient to view the distance chart while his eye was lined up with the axis of the Keratometer. Under the circumstance, the patient could report whether the chart was blurred or clear, and apparent changes in the reflected mire could be noted. Observations on four myopes who are able to "clear" easily seem to show the same changes in the reflected mire of the Keratometer. The mire shows a section defect which may occur in any quadrant. The change presents itself as a flattening of the circle as though caused by a drop of liquid. The effect is not static and the circle continues to shimmer until the effect disappears. This is sometimes fleeting or it may last for 20 or 30 seconds. At the time the ring returns to its normal shape the patient concurrently reports the loss of clear vision.

In connection with these observations, it was felt desirable to have measurements of corneal curvature for the area affected during the interval of clear vision. To this end, a self-illuminated Placedo's disc, having a telescope in the center, was constructed for the purpose of photographing the effect on a glass plate and using the plate for measurement purposes. To date an instrument of sufficient accuracy has not been available in the laboratory.

Another area of interest in these cases, and in fact the point of original interest in seeing this myope, was the possible demonstration of a decrease in refracting power for the eye as a whole during the interval of clear vision. Would there be any change in the distance settings of the haploscope? This myope fell outside the range of the haploscopes available, so the following alternate method was used to determine the position of the far point plane. The patient was placed with his head in a chin rest clamped to the end of a long table. On the table in front of the patient, and extending away from him, was an optical bench. The bench was equipped with a slide which carried a sheet of glass about

30 cm. square upon which was affixed a horizontal line of letters about 1.5 mm. high. The chin rest was arranged so that the patient's visual line for the right eye just grazed the top of the line of print as the patient fixated a single letter projected on a screen 6 meters away. While the patient viewed the blurred letter through the sheet of glass, he was asked to push the plate as far away as possible and still see the line clearly.

Twenty-one settings made on four different days with the subject fixing the distant target gave the following results:

Subject	Distance No. of Settings	Blurred Mean Dist. Cornea	Distance No. of Settings	Clear Mean Dist. Cornea	s	sD	t	*	
W. L.	21	13.56	12	19.08	1.75	.632	8.744	$t_{.01}$	2.75
E. G.	7	13.30	4	17.20	.584	.626	6.389	$t_{.01}$	3.25
B. B.	8	21.09	7	21.40	.556	.288	1.076	$t_{.3}$	1.079
A. G.	9	16.39	3	16.71	.597	.398	.804	$t_{.5}$	.700

* s is the standard deviation of the combined sample: sD the standard deviation of the difference between the means: t indicates the significance of the difference and is compared with t's at various probability levels in the last column.

Under the same conditions normal subjects E. G., B. B., and A. G., made artificially myopic with plus lenses produced the settings shown. It is obvious, of course, that if the distant target is seen clearly it must be in a plane conjugate to the retina at that time, at least within close limits. Whether the setting of the glass plate is a funcion of the present target design has not yet been determined.

SUMMARY

This preliminary report has pointed out that it is possible for some patients, under certain circumstances, to read a test chart by other than normal means. The ability is not the result of "practice effect from reading test charts" and is not the result of "interpretation of blur circles" in the general sense of recognition even though the image is very blurred. The effect does seem to involve corneal changes which provide multiple auxiliary optical systems of small aperture.

Some indications for further study follow:

1. Changes in far point plane with pupil size, with and without "clearing" for the same subject.
2. Ability to clear as a function of distance and pupil size.
3. Measurement of relative brightness of "cleared" pattern as compared to the source with fixed pupil size.
4. Direct photographic investigation of curvature changes in front surface during clearing.

5. Development of a simple practical means for identification when a subject uses "clearing" to report during testing.
6. Elimination or confirmation of liquid film on the corneal surface as the causative factor in producing the phenomenon.

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INSTRUMENT REVIEW

DYNAMIC RAY TRACER. Designed by Henry A. Knoll.

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This is both a visual aid and a nomographic computer useful for the demonstration and calculation of object and image distance and magnification for thin convex and concave lenses and mirrors. The Tracer base is a 6½" diameter white Vinylite disc surfaced with fine black lines for scale readings, and heavy black lines to represent a reference ray diagram. A moveable transparent straightedge pivoted at the center of the disc serves as the "ray through the optical center" and by its intersection with the incident or emergent ray in the diagram accurately and simultaneously shows object size, object position, image size, and image position. By the simple process of assigning relative linear values to the scales, any power of lens or mirror and any combination of object and lens position are represented.

Instructions for its use are included, but they are so brief as to necessitate an elementary knowledge of optics to apply them. The Tracer would have value to anyone doing optical computations, designing, or teaching. An optical problem involving a series of lenses can be solved very rapidly with it, and with little chance for error.

The instrument seems well made, is accurately and very visibly ruled, and can be manipulated smoothly. It is flexible, washable, and should resist normal wear satisfactorily. Price $1.50.

H. W. HOFSTETTER

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AMERICAN JOURNAL OF OPTOMETRY PUBLISHING ASSOCIATION

The American Academy of Optometry and the publishers of this journal have no objection to the reprinting by other magazines of any of the articles in this issue. provided such reprints are properly credited to the AMERICAN JOURNAL OF OPTOMETRY AND ARCHIVES OF AMERICAN ACADEMY OF OPTOMETRY.

COMMENTS ON THE PROBLEM OF FEES*

The recent article, "Suggestions for a New Fee Structure in Optometry," by Koch,[1] qualifies it as one of those occasional articles of high merit that come from within the profession, for the betterment of the profession. Careful study of the article leaves no question in the reader's mind that there was great deliberation in preparing the article, and at the same time much work was done in researching the topic. All phases of optometric development were carefully covered and the diag-

*Editorial written by George H. Warkentine, O.D., Fellow, American Academy of Optometry.

[1]Carel C. Koch. Suggestions for a New Fee Structure in Optometry. July, August, September, October and November issues. American Journal of Optometry and Archives of American Academy of Optometry, 1952.

nosis of the problems of optometry that exist today represents keen insight into the basic structural defects of the profession.

The proposition of offering to the people of our country a service exclusively designed to supply them with the best possible visual care has merit that can be successfully defended against any adverse argument propounded by any group. Such service operating under the name of optometry has proved time and again that this concept of usefulness when properly practiced, is correct. Realizing this, therefore, optometry should constantly improve its own standards until such a state of operation is attained that the end result will present a profession fully qualified in matters of professional behavior: fully qualified in training so as to be in a position to advise competently on visual care, and also fully qualified in matters of economic security so that it can maintain its hard earned position by attracting an adequate supply of desirable young men to perpetuate it. These facets of professional practice were well thought out in Koch's article and we find that the facet that needs the most talking about today, the fee structure facet, was expertly handled. There may be minor differences in the thinking of optometric practitioners who read this article, but as long as these differences are only minor, no concern need be felt by their arising. Perhaps it is safe to say that Koch did not have the slightest hope that his suggestions would be followed to the letter by all of those who needed guidance. But it may also be safe to say that perhaps he did have the modest feeling that since this problem is one of great importance in establishing a profession — and that since there are still glaring examples of commercialism in optometric practice — and that since many practices are maintained on the one fee quotation basis — it was entirely possible that a report of the success experienced by those following this fee structure plan might be of assistance to those not using it, in making a slight change in their method of practice.

Let us look at the picture as a whole then. Koch's article is timely, and is well thought out. It represents the result of actual experiences in successful optometric practices. The author is well aware — as is anyone in our profession who will permit himself to think in an unbiased manner—that when we can in some way make it known that we are entitled to a reasonable compensation for our services: that when we stand ready to admit that the material item of the glasses themselves represents only a minor part of the total cost of visual care, then we can in every way call ourselves a profession in the fullest sense.

I do not mean to imply that I feel the case of a professional charge for a professional service is a problem that has no solution. I firmly be-

lieve that time will be a great influence on the eventual outcome in the light of the forward strides optometry has made in the past 40 years more or less. All who are familiar with optometry's development will admit there has been no such example of progress in the history of any other group related to the so-called "Healing Arts." This rapid growth of optometry may have been because much of the basic science used in its practice was completed before the name of optometry was conceived. Irrespective of what was done before optometric birth, none can deny that as soon as the seed was planted, its destiny was unmistakable, since the usefulness of the profession filled a need in the lives of our civilization. The clear-thinking leaders of the time were persistent in their conviction that here was a profession in spite of its commercial origin. They never lost sight of that objective. Optometric usefulness is more fully realized today then ever before, and the optometric leaders of today are as zealous as always in their efforts to attain the high state our founders dreamed of. This article on fee structure by Koch is an outstanding example of a contribution one of our best leaders of today has made.

If no one heeds all the admonitions of this article it still is not wasted effort by any means. The message it contains clearly points out: Optometry is a profession now qualified by training. It is a profession also qualified by the gains evidenced in the method of professional behavior, which certainly will continue. It will be a completely matured profession when all in it realize that we are professional people and expect to be compensated for our time on a fee basis at a reasonable rate.

We all know in our innermost conscience just where we are deficient. Let those of us who need it most, therefore, permit the truths in this article to influence us a little and if in any way it can alter a practice from nearly professional to totally professional, or one completely commercial to a more professional one, then much is accomplished.

Time will prove this article correct, for truly it is one key to the last frontier optometry must cross.

GEORGE H. WARKENTINE

634 GUARANTY BUILDING,
CEDAR RAPIDS, IOWA.

CHRISTMAS GREETINGS

Once again the Holiday Season is here, giving the Journal staff and Editorial Council a welcome opportunity to thank its thousands of readers and our advertisers for their support during the past year, and wish them a most Merry Christmas and Happy New Year!

TRANSACTIONS OF THE AMERICAN ACADEMY OF OPTOMETRY

A department devoted to announcements, reports, appointments, organization data, news, professional problems and ideals, as these relate to the Academy.

ACADEMY CONVENTION STORY IN JANUARY, 1953

A complete review of the annual convention of the American Academy of Optometry held in Rochester, New York, December 6-9, 1952, will be in the January, 1953, issue of this Journal. Watch for it in the Transactions of Academy section.

LOCAL CHAPTER ACTIVITIES

SOUTHERN CALIFORNIA

The Southern California Chapter heard two speakers at a recent dinner meeting: Dr. Orville D. Caldwell talked on "Physiological Compensatory Changes of the Extrinsic Ocular Muscles Due to Structural Deviation of the Body at Large:" and Fellow Edwin Fletcher gave a resumé of California "Driver Vision Problems."

BRITISH CHAPTER

Mr. A. E. Turville, chapter vice president, lectured on the subject of binocular refraction techniques as applied to the undergraduates of Birmingham University Health Center, at the fall meeting of the British Chapter of the Academy. The next meeting will be held January 19, as a joint meeting with the Contact Lens Society, at the Medical Society of London, 11 Chandos Street, Cavendish Square, London, according to chapter secretary, Mr. Eric Bateman.

IOWA CHAPTER

A two-day educational session with five speakers was sponsored by the Iowa Chapter of the Academy at Marshalltown, Iowa, on November 30 and December 1. Dr. R. G. Schiller, and Drs. Otis, Russell and Henry Wolfe spoke on "Glaucoma," "Motility," and "Aphakic Rx and Problems With Patients." Other speakers were M. D. Getman, on "How to be Happy in Your Profession," Dr. Dale Harris, "Diabetes and Its Relation to Eyes." All Iowa optometrists were invited to attend.

NEW YORK ACADEMY

Dr. Harold Solan, Fellow of the New York Academy of Optometry, spoke on the "Role of the Optometrist in Reading Problems," at a recent meeting of the chapter. Dr. Solan is on the teaching staff of Columbia University School of Optometry.

CURRENT COMMENTS

Virginia Huck
Editorial Assistant

Optometrists will confer a favor by sending news items of general interest for this department: such as relate to new instruments, clinical techniques, education, visual health and optometric legislation and organization.

PRANGEN HONORED BY COMMITTEE

The National Interprofessional Committee on Eye Care, at its Fall meeting in Chicago, Illinois, made Dr. Avery D. Prangen, Rochester, Minnesota, Life Chairman Emeritus of the committee in recognition of his leadership in bringing about better relations between ophthalmology, optometry, and opticianry. Dr. Prangen resigned from the committee just prior to this Fall meeting because of ill health, after serving as chairman since its organization two years ago.

The resolution making Dr. Prangen Life Chairman Emeritus in honor of his "distinguished and meritorious service to the National Interprofessional Committee on Eye Care" was made part of the minutes of this October 12 meeting.

At the same meeting the following officers were elected: Dr. Arthur M. Culler, Section on Ophthalmology, Medical School, The Ohio State University, Columbus, Ohio, chairman; Mr. Leslie Myers, chairman of the board, N. P. Benson Optical Company, Minneapolis, Minnesota, vice chairman; Dr. Carel C. Koch, Editor, *American Journal of Optometry and Archives of American Academy of Optometry*, secretary.

DONDERS' CLASSIC AGAIN AVAILABLE IN ENGLISH

F. C. Donders' classic, "Accommodation and Refraction of the Eye," has been re-issued in its original format, in a limited edition, by The Hatton Press, Ltd., 72/78 Fleet Street, London, E. C. 4, England. (Price, United Kingdom, £3 3s. U. S. and Canada, $9.00.) Only one previous edition of this book has been published in English, in 1864, by the New Sydenham Society. The Hatton Press has published 1,000 copies, many of which have already been sold. This new edition is an exact reproduction of the original text and diagrams; the format, typography and paper are also based on the 1864 edition.

MEETINGS

FALL INSTITUTE—MISSOURI VALLEY OPTOMETRIC SOCIETY

"Vision, Visual Aids and Learning," was the theme of the annual Fall institute of the Missouri Valley Optometry Society, attended by

optometrists, illuminating engineers, and educators. Co-sponsors of the institute were the Cornhusker Chapter of the Illuminating Engineering Society and the College of Adult Education of the University of Omaha. Nine speakers talked on seeing and the use of visual materials in the classroom: Dr. John Stroud, Navy Electronics Laboratory, San Diego, California, "Brains and Learning-Human vs. Electronic:" Dr. Lincoln Miller, Illinois State Normal University, "The Place of Visual Aids in the Modern Educational Program:" Mr. S. K. Guth, General Electric Lamp Research Division, Nela Park, Cleveland, Ohio, "The Best Surroundings for Presenting Visual Aids:" Mrs. Bette Erickson, Director, Bureau of Teaching Aids, University of Omaha, "Remedial Reading Materials and Methods:" Dr. James Wright, optometrist, "The Vision Specialist as a Visual Aid to Learning:" Dr. C. V. Arnspiger, Executive Vice President, Encyclopedia Britannica Films, Inc., "Materials that Produce Results with the Child:" Clifford Welch, Director, United States Naval Training Aid Center, Treasure Island, San Francisco, "Visual Aid Uses and Classroom Adaptations."

Following the program a panel discussion moderated by Society President G. N. Getman, was held. The Institute took place at the University of Omaha, Ohama, Nebraska.

FALL WORKSHOP—IOWA OPTOMETRIC ASSOCIATION

Dr. Carl Shepard, Chicago, and Harold Kohn, New York City, were the principal speakers at the annual Fall Workshop sponsored by the Iowa Optometric Association October 26-27. The workshop drew 140 optometrists—nearly half of Iowa's practicing optometrists, according to I. O. A. president M. W. Getman.

Dr. Shepard discussed the research behind the development of the new A. O. A. visual recognition chart; Mr. Kohn, the problems facing optometry on a nationwide basis.

Seminars on the "coordinated classroom" were also held, with Drs. W. B. Kennedy, Cresco, Paul W. Thielking, Des Moines, B. W. Scott, Independence, and Norman W. Kilburn, West Union, the speakers. Dr. Kennedy, who has been working on visual problems in the Howard County, Iowa, schools, presented color slides showing schoolrooms before and after the application of better lighting and color principles. Dr. James Manville, Cedar Rapids, was chairman of this seminar program.

At its business session, an honorary life fellowship in the Iowa Optometric Association was presented to Dr. T. M. Buchanan, Waterloo, Iowa, a member of I. O. A. since 1908.

NORTH CAROLINA STATE OPTOMETRIC SOCIETY

The Fall educational convention of the North Carolina State Optometric Society was held in Raleigh, November 30-December 2, with Dr. Louis Jacques, Sr., the principal speaker. Also featured at the three-day session was a report by Dr. D. J. Moffee, Director, Psychology Department, North Carolina State College, on occupational vision work at the College.

UNIVERSITY OF WISCONSIN INDUSTRIAL VISION INSTITUTE

An institute on relationships in industrial vision was held on the University of Wisconsin campus December 13, 14 for the benefit of optometrists in Wisconsin, Minnesota, Iowa, Illinois, Indiana and Michigan. The program was planned to give optometrists a broad survey of the many individuals, groups, organizations and programs in industry which have a part in special personnel programs including industrial vision programs. Stress was placed on the need for co-operation among these various groups and individuals, and part of the program was devoted to optometric cooperation in industrial vision programs. The speakers and their topics were as follows: Dr. Charles S. Bridgman, director, Bureau of Industrial Psychology, U. of W., "Plan of the Institute." Dr. L. E. Lerdall, chairman, W. O. A. committee on industrial relations, "The Interests of Optometrists in Occupational Vision." Arnold Nielsen, director of training, Wisconsin Electric Power Company, "The Purpose, Structure and Achievements of the Modern Personnel Program." Karl U. Smith, professor of psychology, U. of W., "Employee Attitudes: Psychological Factors in Establishment and Functioning of Special Personnel Programs." E. A. Page, safety supervisor, Kimberly Clark Corporation, "A Balanced Safety Program." Robert Ozanne, director, School for Workers, U. of W., "The Union and Industrial Vision Program." J. Daniels, U. S. Fidelity and Guaranty Insurance Company, "The Economics of Compensation and Industrial Insurance." Sylvester K. Guth, director of Lighting Research, Lamp Division, General Electric Company, "Illumination Engineering and Industrial Vision Programs." Dr. Monroe J. Hirsch, Los Angeles College of Optometry, "Methods of Visual Screening." Dr. Henry Hofstetter, Director, Division of Optometry, Indiana University, "Types of Industrial Vision Programs." Dr. Hedwig Kuhn, Hammond, Indiana, "The Complete Industrial Vision Program." Guest speaker at the banquet was Dr. Edwin Wittee, professor of economics, U. of W., who spoke on "Age Trends in Our Population."

The closing session was devoted to a panel discussion on the possibilities, problems and pitfalls in industrial vision programs, with Dr.

Hofstetter moderating, and Ellery J. Gallenbach, safety director, Malleable Iron Range Company and members of the W. O. A. committee on industrial relations participating.

CALIFORNIA OPTOMETRIC ASSOCIATION GRADUATES' CONFERENCE

The California Optometric Association sponsored its annual graduates' conference in two sections this year, one at the Los Angeles College of Optometry and one at the University of California School of Optometry, both on December 14. Public relations, practice building, bookkeeping and office procedure were discussed. The conference is especially for those graduates who have been practicing four years or less, but any graduate may attend and participate.

NEWS BRIEFS

The Aniseikonic Forum is working on a new directory which will include those who have recently added space eikonometers to their office equipment. Aniseikonic practitioners are now located in England, France, Italy, Egypt, Sweden, Australia, New Zealand, Brazil and Panama, in addition to the United States and Canada. The Forum is also working on a manuscript, "Difficulties Encountered in the Space Eikonometer Test," which will be the result of consultation with several aniseikonic practitioners. . . . Dr. Evelyn B. Robinson, Sylacauga, Alabama, has been named "Woman of the Year," by the Sylacauga Exchange Club, in recognition of her activities in local educational, civic, religious and charitable organizations. Dr. Robinson is serving her seventh term as secretary-treasurer of the Alabama Optometric Association, of which her husband, Dr. J. Kelley Robinson, is president. . . . A Chicago-originated TV show, "Mr. Wizard," was awarded a citation by Bausch and Lomb Optical Company for outstanding contributions to science education. Don Herbert, "Mr. Wizard," accepted the award on the November 15 telecast. . . . Wives of optometry students at Pacific University attended the College's third annual seminar sponsored especially for them. Topics included lay discussions of visual skills and visual training, ocular anatomy, geometrical optics, mechanical optics, physiology of vision, optometric instruments, office procedures. . . . South Dakota is now the only state which does not require an examination for driving, issues no license and sets no legal standard for automobile drivers, except a 15-year minimum age, according to American Optical Company's latest survey on state requirements for motor vehicle operators. . . . A ceremony dedicating a plaque commemorating the efforts of organized optometry toward the construction of Jefferson Hall, Pacific University College of Optometry's new home, will be the first official item on the program of the 1952 Northwest Congress.

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ABSTRACTS

AMERICA IS GROWING—ARE YOU? Dr. Vergil D. Reid. Printer's Ink. 29-31. October 10. 1952.

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This article indicates that some city governments, some large utility and other concerns, some agricultural agencies, etc., are making plans to cope with this tremendous population increase.

It may not be out of order to ask if optometry is making preparations to provide for the great increase in the number of school children and elderly people who will need competent visual care.

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c. Do TV or movies bother you?
d. Notice any discomfort symptoms before watching television?
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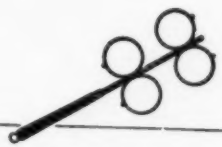

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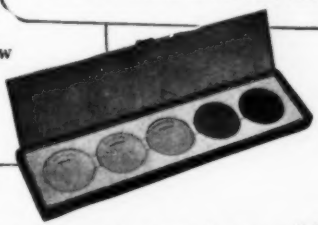

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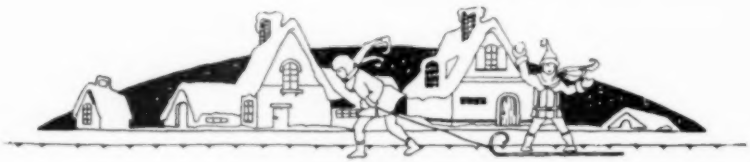

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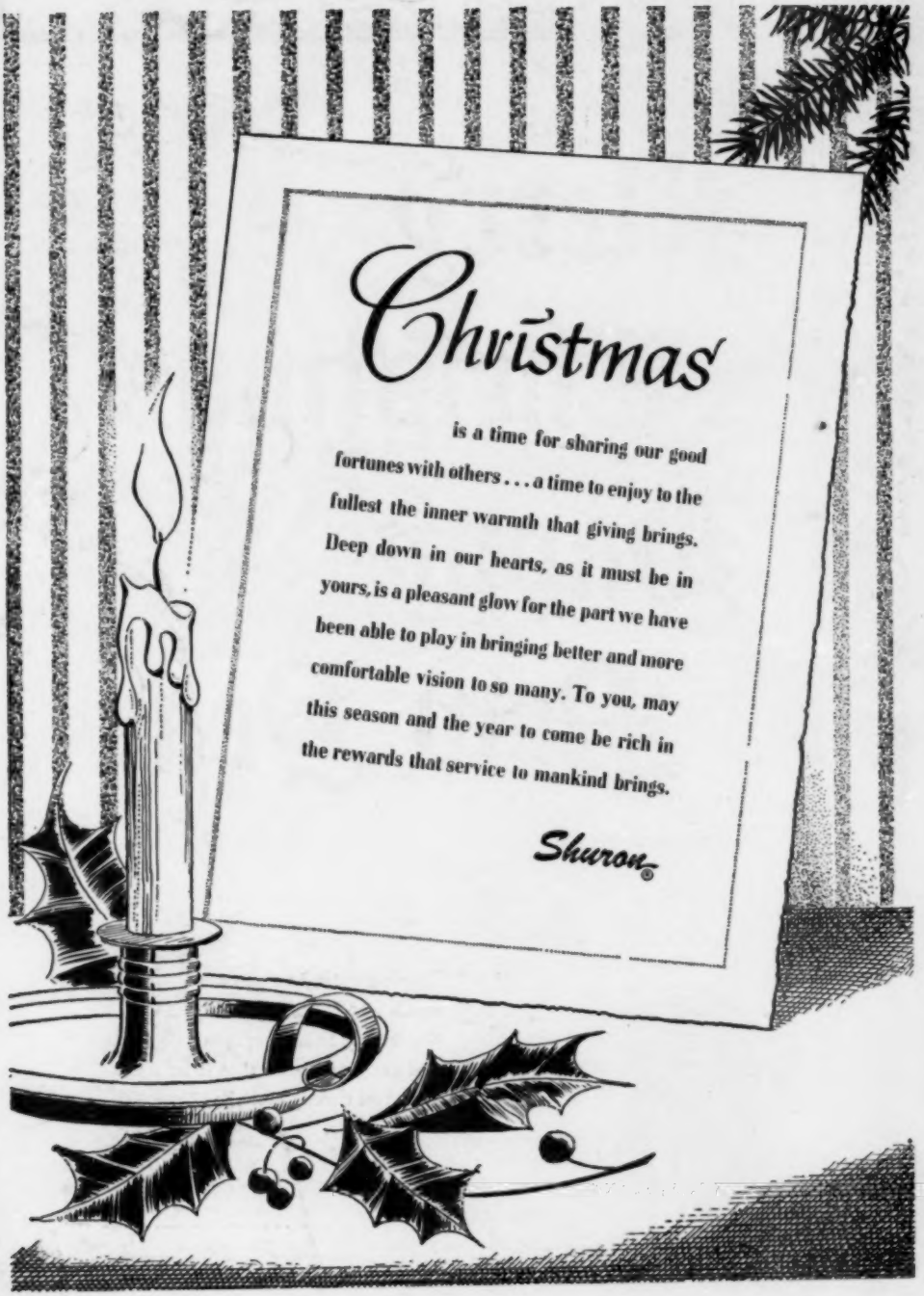
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